CHAPTER II - RECONNAISSANCE & FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate and timely meteorological information in support of each warning. JTWC relies primarily on three sources of reconnaissance: aircraft, satellite and radar. Optimum utilization of all available reconnaissance resources is obtained through use of the Selective Reconnaissance Program (SRP) whereby various factors are considered in selecting a specific reconnaissance platform for each warning. These factors include: cyclone location and intensity, reconnaissance platform capabilities and limitations, and the cyclone's threat to life/property afloat and ashore. A summary of reconnaissance fixes received during 1978 is included in Section 6.

2. RECONNAISSANCE AVAILABILITY

a. Aircraft:

Aircraft weather reconnaissance is performed in the JTWC area of responsibility by the 54th Weather Reconnaissance Squadron (54 WRS). The squadron, presently equipped with six WC-130 aircraft, is located at Andersen Air Force Base, Guam. From July through October, augmentation by the 53rd WRS at Keesler Air Force Base, Mississippi brings the total number of available aircraft to nine. The JTWC reconnaissance requirements are provided daily throughout the year to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC). These requirements include area(s) to be investigated, tropical cyclone(s) to be fixed, fix times and forecast positions of fixes. The following priorities are utilized in acquiring meteorological data from aircraft, satellite and land-based radar in accordance with CINCPACINST 3140.1N:

"(1) Investigative flights and vortex or center fixes for each scheduled warning in the Pacific area of responsibility. One aircraft fix per day of each cyclone of tropical storm or typhoon intensity is considered the minimum desired.

(2) Center or vortex fixes for each scheduled warning of tropical cyclones in the Indian Ocean Area of responsibility.

(3) Supplementary fixes.

(4) Synoptic data acquisition."

As in previous years, aircraft reconnaissance provided direct measurements of height, temperature, flight-level winds, sea level pressure, estimated surface winds (when observable) and numerous additional parameters. The meteorological data are gathered by the Aerial Reconnaissance Weather Officers (ARWO) and dropsonde operators of Detachment 4, Hq AWS who crew with the 54th. These data provide the Typhoon Duty Officer (TDO) indications of changing cyclone characteristics, radius of cyclone associated winds, and present cyclone position and intensity. Another important aspect of this data is its availability for research in tropical cyclone analysis and forecasting. Aircraft reconnaissance will become even more important in years to come when high-resolution tropical cyclone dynamic steering programs will require a dense input of wind and temperature data.

b. Satellite

Satellite fixes from USAF ground sites and USN ships provide day and night coverage in the JTWC area of responsibility. Interpretation of this satellite imagery provides cyclone positions and estimates of storm intensities through the Dvorak technique (for daytime passes).

Detachment 1, 1st Weather Wing is the primary fix site for the western North Pacific. Both DMSP and NOAA data are received and processed. DMSP fix positions received at JTWC from the Air Force Global Weather Central (AFGWC), Offutt Air Force Base, Nebraska were the major source of satellite data for the Indian Ocean. GOES fixes were also provided by the National Environmental Satellite Service, Honolulu, Hawaii for tropical cyclones near the dateline.

c. Radar

Land radar provides positioning data on well developed cyclones when in proximity (usually within 175 nm of the radar site) of the Republic of the Philippines, Taiwan, Hong Kong, Japan, the Republic of Korea, Kwajalein, and Guam.

3. AIRCRAFT RECONNAISSANCE SUMMARY

During the 1978 tropical cyclone season, JTWC levied 290 six-hourly vortex fixes (Table 2-1). New storm tracks developed by Det 4, AWS and JTWC increased the number of supplemental fixes from 4 in 1977 to 149 in 1978. These tracks require reconnaissance aircraft to penetrate a tropical cyclone twice on a one-fix mission and three times on a two-fix mission; the extra fix is termed supplemental. In addition to vortex fixes, 38 investigative missions were levied (the 1976-1978 average is 38 invests). Of 1978's 32 tropical cyclones, investigative missions were not flown on nine.

Reconnaissance effectiveness is summarized in Table 2-1 using the criteria as set forth in CINCPACINST 3140.1N.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS	NUMBER OF FIXES	PERCENT
COMPLETED ON TIME	272	93.8
EARLY	6	2.1
LATE	10	3.4
MISSED	2	0.7
TOTAL	290	100.0

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	7.6
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5
1978	290	2	0.7

4. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC using meteorological data from DMSP polar orbiting meteorological satellites.

A network of tactical DMSP sites at Nimitz Hill, Guam; Clark AB, Philippines; Kadena AB, Japan; Osan AB, Korea; and Hickam AFB, Hawaii provides direct readout coverage north of the equator from the dateline west into the South China Sea. In February 1977, the Guam site was modified to acquire very high resolution data from the National Oceanic and Atmospheric Administration (NOAA) satellites. The Hawaii site was modified soon thereafter.

The Air Force Global Weather Central (AFGWC) at Offutt AFB, Nebraska, using stored data readout, provides satellite reconnaissance over the Indean Ocean and backup for the tactical sites in WESTPAC. Det 1, 1WW colocated with the JTWC, operates the network tasking appropriate sites for tropical cyclone position reports.

Satellite positions are assigned Position Code Numbers (PCN's) depending on the availability of geography for precise gridding and the state of the tropical cyclone's circulation (Table 2-2). Estimates of tropical cyclone intensity are obtained from visual data using the Dvorak technique (NOAA Technical Memorandum NESS 45 and later refinements).

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

CC=Circulation Center

Availability of satellite data enabled JTWC to effectively use satellite reconnaissance through the Selective Reconnaissance. Program (SRP). During the 1978 season over 1900 satellite fixes were made on unnumbered as well as numbered tropical cyclones in WESTPAC.

By using a dual-site tasking concept which requires at least two separate DMSP sites to make each JTWC levied tropical cyclone fix, satellite reconnaissance reliability in meeting JTWC's fix requirements was 96%. Most missed fixes were due to an unreliable late morning/late evening satellite. Because of this satellite's unreliability, aircraft reconnaissance routinely supported 0600Z and 1800Z warnings with radar and NOAA-5 satellite data also being used on occasion. Use of the NOAA-5 satellite for fixing tropical cyclones ended in September 1978 when the satellite became too unstable for accurate positioning.

A comparison of satellite derived positions and the JTWC Best Track positions is included in Table 2-3. The relative accuracies of satellite positions can be obtained from this table.

TABLE 2-3. MEAN DEVIATIONS (NM) OF DMSP DERIVED TROPICAL CYCLONE POSITIONS FROM JTWC BEST TRACK POSITIONS, 1974-1978 (ALL SITES). NUMBER OF CASES SHOWN IN PARENTHESIS.

PCN	1974 (ALL SITES)	1975 (ALL SITES)	1976 (ALL SITES)	1977 (ALL SITES)	1978 (ALL SITES)
1	13.6 (224)	11.8 (214)	12.4 (131)	15.7 (134)	13.8 (189)
2	17.4 (37)	20.4 (35)	20.1 (124)	19.1 (47)	16.0 (95)
3	20.1 (422)	21.2 (271)	21.7 (161)	22.4 (141)	21.9 (353)
4	23.9 (70)	22.4 (50)	29.3 (152)	30.0 (75)	21.8 (156)
5	35.4 (342)	34.2 (323)	40.4 (247)	37.7 (357)	38.1 (571)
6	49.4 (108)	44.7 (71)	49.0 (153)	40.9 (247)	50.5 (370)
1&2	14.2 (261)	13.0 (249)	16.1 (255)	16.6 (181)	14.6 (284)
3&4	20.6 (492)	21.4 (321)	25.4 (313)	25.0 (216)	21.9 (509)
5&6	38.8 (450)	36.1 (394)	43.7 (400)	39.0 (604)	43.0 (941)

Satellite derived fixes were also obtained from: USN ships equipped for DMSP or TIROS-N/NOAA APT direct readout; the National Environmental Satellite Service using NOAA and GOES data; and Fleet Weather Facility (FLEWEAFAC), Suitland, Maryland using stored NOAA and DMSP data. This information was invaluable to the warning service. Since these were secondary sources, they were not included in statistics.

5. RADAR RECONNAISSANCE SUMMARY

Fifteen of the 32 significant tropical cyclones occurring over the western North Pacific during 1978 passed within range of land based radars with sufficient cloud pattern organization to be fixed. The hourly and oftentimes, half-hourly land radar fixes that were obtained and transmitted to JTWC totaled 848. A percentage breakdown by country is as follows: Japan-Ryukyu Islands 62%, Republic of the Philippines 18%, Hong Kong 8%, Guam (U.S.) 7%, and Taiwan 4%.

The WMO radar code defines three categories of accuracy: good (within 10 km (5.4 nm)), fair (within 10-30 km (5.4-16.2 nm)) and poor (within 30-50 km (16.2-27 nm)). This year 308 radar fixes were coded in this manner; 49% were good, 20% fair and 31% poor. Compared to the JTWC best track, the mean vector deviation for land radar sites was 13 nm (24 km).

Of the 15 tropical cyclones which were monitored with radar, 10 were typhoons (Olive, Virginia, Wendy, Carmen, Elaine, Faye, Irma, Lola, Ora and Rita). These 10 typhoons accounted for 74% of all radar fixes received this season. Excellent support through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult and erractic tracks.

The 54 WRS made four radar center fixes from their WC-130 aircraft when actual penetration was restricted. One aircraft radar fix of TC 20-78 when over the Arabian Sea was relayed to JTWC from Diego Garcia. No ship radar center fixes were received during 1978.

6. TROPICAL CYCLONE FIX DATA

A total of 3172 fixes on 32 northwest Pacific tropical cyclones and 117 fixes on four northern Indian Ocean tropical cyclones were received at JTWC. Table 2-4, Fix Platform Summary, delineates the number of fixes per platform for each individual tropical cyclone. Season totals and percentages are also indicated.

Annex B is an output of program PRNTFIX which lists individual fixes sequentially for each tropical cyclone. Fix data is divided into three categories; Satellite, Aircraft and Radar. Those fixes labeled with an asterisk (*) were determined to be unrepresentative of the surface center and were not used in determining the best tracks. Within each category, the first three columns are as follows:

FIX NO. - Sequential fix number

TABLE 2-4. FIX PLATFORM SUMMARY

	FIX PLATFORM						
	AIRCRAFT*	DMSP	NOAA-5	GOES	LAND RADAR	ACFT RADAR	TOTAL
WESTERN PACIFIC							
TS NADINE	9	29	24	3	-	-	65
TY OLIVE	25	66	23	-	17	-	131
TS POLLY	35	58	12	-	124	-	209
TS ROSE	7	25	7	-	-	-	39
TS SHIRLEY	-	21	6	-	-	1	28
TY TRIX	29	84	18	-	-	-	131
TY VIRGINIA	36	85	6	-	42	-	169
TY WENDY	26	130	7	-	100	-	263
TS AGNES	-	63	6	-	50	-	119
TS BONNIE	-	15	4	-	-	-	19
TY CARMEN	22	104	12	-	125	-	263
TS DELLA	6	22	2	-	9	-	39
TD 14	6	24	6	-	2	-	38
TY ELAINE	12	38	14	-	24	-	88
TY FAYE	45	87	6	-	9	-	147
TS GLORIA	7	36	1	-	-	-	44
TS HESTER	1	31	-	-	-	-	32
TY IRMA	7	41	-	-	72	2	122
TY JUDY	14	50	-	-	-	-	64
TS KIT	12	50	-	-	-	-	62
TY LOLA	17	90	-	-	29	-	136
TY MAMIE	12	38	-	-	-	-	50
TS NIKA	16	74	-	-	34	-	124
TY ORA	18	59	-	-	96	-	173
TD 26	-	17	-	-	-	-	17
TD 27	2	28	-	-	-	-	30
TY PHYLLIS	8	58	-	-	-	1	67
ST RITA	43	110	3	5	115	-	276
TS TESS	17	42	-	-	-	-	59
TD 32	-	36	-	-	-	-	36
TY VIOLA	22	70	-	-	-	-	92
TS WINNIE	12	28	-	-	-	-	40
TOTAL	446	1709	157	8	848	4	3172
% OF TOTAL NO. OF FIXES	14.1	53.9	4.9	.3	26.7	.1	100

	DMSP	TIROS-N	ACFT RADAR	TOTAL
INDIAN OCEAN				
TC 18-78	21	-	-	21
TC 19-78	13	-	-	13
TC 20-78	30	6	1	37
TC 21-78	40	6	-	46
TOTAL	104	12	1	117
% OF TOTAL NO. OF FIXES	88.9	10.2	.9	100

* FIX POSITIONS QUOTED WERE ONLY THOSE WHERE A SPECIFIC LATITUDE AND LONGITUDE WERE GIVEN.

TIME (Z) - GMT time in day, hours and minutes

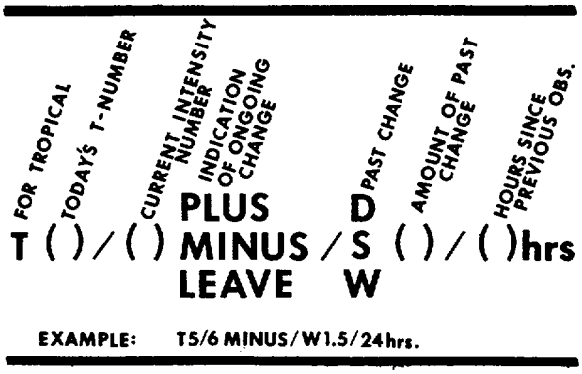
FIX POSITION - Latitude and longitude to the nearest tenth of a degree

Depending upon the category, the remainder of the format varies as follows:

a. Satellite

(1) ACCRY - Position Code Number (PCN) (See Sec. 5). The accuracy for FWF Suitland fix positions are given as confidence numbers (CONF) (See Table 2-5 for details).

(2) DVORAK CODE - Intensity evaluation and trend utilizing DMSP visual satellite data.



EXAMPLE: T5/6 MINUS/W1.5/24hrs.

(For specifics refer to NOAA TM; NESS-45)

TABLE 2-5. CONFIDENCE (CONF) NUMBERS AS A FUNCTION OF DVORAK T NUMBER AND RADIUS OF 90% PROBABILITY AREA (NM).

TROPICAL CYCLONE INTENSITY	CONF (1)	CONF (2)	CONF (3)
T1.5	60	120	170
T2.0	60	120	170
T2.5	60	120	170
T3.0	50	100	150
T3.5	45	90	140
T4.0	45	90	140
T4.5	45	90	140
T5.0	40	90	130
T5.5	40	80	130
T6.0	40	80	130
T6.5	30	70	120
T7.0	30	70	120
T7.5	30	60	100
T8.0	30	60	100

(3) SAT - Specific satellite used for fix position (DMSP 35, 36 or 37, NOAA-5, TIROS-N, or Geostationary Operational Environmental Satellite (GOES)).

(4) COMMENTS - For explanation of abbreviations see Appendix.

(5) SITE - ICAO call sign of the specific satellite tracking station.

b. Radar

(1) RADAR - Specific type of platform utilized for fix (land radar site, aircraft or ship).

(2) ACCRY - Accuracy of fix position (good, fair or poor) as given in the WMO ground radar weather observation code (FM20-V).

(3) EYE SHAPE - Geometrical representation of the eye given in plain language (Circular, Elliptical, etc.).

(4) EYE DIAM - Diameter of eye given in nautical miles.

(5) RADOB CODE - Taken directly from WMO ground weather radar observation code FM20-V. First group specifies the vortex parameters while the second group describes the movement of the vortex center.

(6) RADAR POSITION - Latitude and longitude of tracking station given in tenths of a degree.

(7) SITE - WMO station number of the specific tracking station.

c. Aircraft

(1) FLT LVL - The constant pressure surface level, in mb, maintained during the penetration. 700 mb is the normal level flown in developed cyclones due to turbulence factors with low level missions flown at 1500 ft.

(2) MIN HGT - Minimum height of the 700 mb pressure surface within the vortex recorded in meters.

(3) OBS MSLP - The minimum observed sea level pressure on a 700 mb fix mission is obtained by applying the minimum 700 mb height to the following regression equation:

SLP (MB)=.115 (700 mb HGT [M]) + 645

This relationship is accurate within ± 3 mb in most cases. However, if the 700 mb center and the surface center are not vertically alligned, the minimum sea level pressure will be erroneously high. If the surface center can be visually detected (e.g., in the eye), the minimum sea level pressure is obtained by a dropsonde released above the surface vortex center.

If the fix is made at the 1500 foot level, the sea level pressure is extrapolated from that level.

(4) MAX-SFC-WND - The maximum surface wind (knots) is an estimate made by the ARWO based on sea state. This observation is limited to the region of the flight path, and may not be representative of the entire cyclone. Availability of data is also dependent upon the absence of undercast conditions and the presence of adequate illumination. The positions of the maximum flight level wind and the maximum observed surface wind do not necessarily coincide.

(5) MAX-FLT-LVL-WND - Wind speed (knots) at flight level is measured by the AN/APN 147 doppler radar system aboard the WC-130 aircraft. Values entered in this category represent the maximum wind measured prior to obtaining a scheduled fix. This measurement may not represent the maximum flight level wind associated with the tropical cyclone because the aircraft only samples those portions of the tropical cyclone along the flight path. In many instances the flight path may be through the weak sector of the cyclone. In areas of heavy rainfall, the doppler radar may track energy reflected from precipitation rather than from the sea surface; thus preventing accurate wind speed measurement. In obvious cases such erroneous wind data will not be reported. In addition, the doppler radar system on the WC-130 restricts wind measurements to drift angles less than or equal to 27 degrees if the wind is normal to the aircraft heading.

(6) ACCRY - Fix position accuracy. Both navigational (OMEGA and LORAN) and meteorological (by the ARWO) estimates are given in nautical miles.

(7) EYE SHAPE - Geometrical representation of the eye based on the aircraft radar presentation. Reported only if center is 50% or more surrounded by wall cloud.

(8) EYE DIAM/ORIENTATION - Diameter of the eye in nautical miles. In case of elliptical eye, the orientation describes the nautical mile lengths of the major and minor axes.